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Subject: Proposal for beam experiments on barrier rf stacking

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In the past two months, a group of people has been working on a beam stacking scheme in the Main Injector by using a barrier rf system. It is an alternative to the slip stacking. The goal is to inject more than 6 batches of Booster beams into the MI so that the proton intensity on the p-bar production target as well as on the NuMI target could be increased.

This scheme is based on the following fact: The momentum acceptance of the MI (±0.7%) is larger than the momentum spread of the Booster beam. This makes stacking in the longitudinal phase space possible. The basic idea is to apply a barrier rf system to reduce the injected beam length by increasing its momentum spread so that more (> 6) Booster batches could fit into the MI.

This study has three stages:

Stage I: Paper study (simulations and calculations);
Stage II: Beam experiments;
Stage III: Hardware development.

At this moment, the first stage, namely the paper study, has been completed. The main conclusions are:

1. This scheme works well on paper. Its main advantage is to allow a continuous injection of 10-12 batches (number depending on the initial dp/p of the Booster beam) from the Booster to the MI. This would give the MI about a 70-100% increase in protons per pulse, or about 45-60% increase in protons per second.
2. Compared to the slip stacking, the beamloading effect of this method is moderate, because the peak beam current is lower. (It is virtually a debunched beam during stacking).
3. The key issue is the momentum spread of the beam from the Booster, which has to be small (about ±6 MeV) for this scheme to work. Simulations show that this is achievable by either a bunch rotation or an adiabatic compression with a second harmonic rf in the Booster.
4. The required hardware (a 10 kV barrier rf system) looks feasible.

We propose to advance this study to Stage II and perform the following beam experiments:

A. In the Booster:

Bunch rotation at high beam intensities, including an investigation of beam instability suppression. (This is an on-going activity by K. Koba and B. Pellico. We ask it be given a higher priority.)

B. In the Recycler:
   1) Beam squeezing at various barrier bucket moving speed.
   2) Beam stacking using injected beams with a momentum offset.

C. In the Main Injector:
   Debunching and recapture of 53 MHz bunches at 8 GeV.

In addition, we also propose to carry out an MI rf cavity test by lowering its screen voltage from 2 kV to -100 V. Calculation shows that this could reduce the beamloading effect by a factor of 3-4, which would be enough for this scheme.

If the beam experiments are successful, we will then make a proposal for hardware development as part of the Run 2b program.

List of participants in the barrier rf stacking study:

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